DRAFT

THE POTENTIAL FOR RENEWABLE ENERGY IN WISCONSIN
February 10, 2005

This is a draft document under development. All comments are welcome. This is being distributed as a document to serve the discussion of the solar energy markets to take place on February 15 at the Energy Center of Wisconsin. A similar document outlining the agricultural anaerobic digestion, commercial wind, and waste wood for heat markets will be distributed soon.

Non Energy Benefits of Renewable Energy

The concept of "clean energy" depends for its particular value on its non-energy benefits. While this value has not yet been fully quantified, it is certainly being recognized. It is therefore essential to note that renewable generation technologies like solar PV provide non-energy benefits, particularly in the areas of environmental quality and economic development.

Renewable Energy Markets

This study will explore the achievable potential of the following solar technologies in Wisconsin:

1. Customer sited, grid connected photovoltaic systems on commercial businesses, including building-integrated photovoltaic systems (BIPV). BIPV includes PV technology imbedded in roofing materials, glass and building façade materials, and other architectural features. Applications of BIPV technologies also include institutional buildings and other structures designed to incorporate efficiency and other green building standards. (photo of Mary Coffrin Hall, UW-Green Bay)
2. Solar water heating systems for commercial enterprises and institutions that require high volumes of hot water, such as hotels, car washes, laundries, hospitals, health clubs, collegiate athletic facilities and municipal pools.
3. Solar water heating systems for single-family residential applications, both existing homes and new home construction, including the potential for the zero-energy home concept, where builders offer high efficiency homes with solar systems offered as options like appliances.
4. Agricultural anaerobic digestion for heat and power, employing animal manure, as applied on large and medium-sized livestock operations, and for cooperative of smaller operations.
5. Customer-sited commercial-scale wind turbines on farms and rural businesses
6. Wood residue waste for heating manufacturing facilities and commercial and institutional buildings.

SOLAR ENERGY TECHNOLOGIES

Resource characterization: Solar Energy

Three of the markets addressed by this study are for solar technologies: commercial photovoltaics (solar PV), commercial/institutional solar thermal (water heating) and

residential solar thermal. All three employ panels known as flat plate technologies. These panels, for both electrical generation (solar PV) and water heating (solar thermal), use the sun's ambient light and heat, and do not employ mirrors or other optical elements to concentrate the sun's energy. Therefore, they function well in both direct and diffuse sunlight, unlike solar concentrator technologies which require high concentrations of direct sunlight to function reliably. Solar concentrator technologies work best in locations like the desert of the Southwest which has few cloudy days. Flat plate technologies perform well in many climates with varying degrees of cloud cover such as the Upper Midwest.

The solar resource for flat plate systems in Wisconsin is characterized by the National Renewable Energy Laboratory (NREL) as "good," ranging from 4.0 to 5.0 kWh per square meter per day.[1] Generally speaking, the potential is slightly higher in the western half of the state. Wisconsin's potential compares in range to the photovoltaic solar resource in Indiana, Ohio and Michigan, but is less than Minnesota and Illinois, and states farther west and south.

A table from the U.S. DOE Energy Efficiency and Renewable Energy (EERE) web site[2] shows a comparison of average photovoltaic system size requirements in different locations around the United States. While no location in Wisconsin is included, comparisons among a number of other Midwestern cities indicate that Wisconsin would fall well within the moderate potential range. Locations with extremes are shown for further comparison.

City	Meters^2 of PV panels required*
Albuquerque, NM	6.4
Los Angeles CA	7.3
Kansas City, MO	8.4
Bismarck, ND	8.4
Minneapolis, MN	8.9
Chicago, IL	9.3
Cleveland, OH	10.0
Seattle, WA	11.1
Anchorage, AK	13.7

**Comparison in square meters of PV panel system based on a comparable home that uses 6000 kWh/yr, obtains 25% from PV, and uses 10%-efficient flat plate collector facing south at latitude angle*

[1] National Renewable Energy Laboratory (NREL) Map, *PV Solar Radiation (Flat Plate, Facing South, Latitude Tilt), Annual average.* "Model estimates of monthly average daily total radiation using inputs derived from satellite and/or surface observations of cloud cover, aerosol optical depth, precipitable water vapor, albedo, atmospheric pressure and ozone resampled to a 40km resolution." Map at http://www.nrel.gov/gis/images/us_csp_annual_may2004.jpg

[2] (EERE data: www.eere.energy.gov/consumerinfo/makeeelectricity/eval_pv_collector_size.html)

Solar technologies are particularly appropriate in urbanized settings. Both electric and thermal solar systems can be installed on existing buildings. These systems are quiet to operate and require little maintenance. Furthermore, both solar PV and solar thermal applications offset use of fossil fuels. Photovoltaic systems can replace coal and natural gas use, while solar thermal applications replace or augment the use of natural gas and propane.

1. Commercial Photovoltaic Systems

Bringing what has been an essentially grass roots technology into the main stream business world is not as far a stretch as would first appear. Economics are beginning to favor clean energy alternatives for commercial applications because of federal tax advantages, accelerated depreciation, and time-of-use utility rates. Furthermore, volatile fossil fuel markets, growing public pressure to increase regulatory controls on greenhouse gasses, and new concerns about energy security are driving interest in solar PV among commercial and institutional power customers. New financing options, state and federal incentives, and easier access to grid interconnection also play an important role.

In recent years there has been notable growth in grid connected solar PV both nationally and internationally. A May, 2004 Solarbuzz report states that "37 Megawatts of grid-connected solar photovoltaics were installed in the United States in 2003. This represents growth of 32% over 2002 installations of 28 megawatts."[3] While the residential market is currently growing the fastest, the potential for customer sited commercial PV installations is huge, as distributed generation (DG) strategies become more appealing to both businesses and utilities. For businesses with high quality power needs, a solar PV system with a battery bank can be integrated with a UPS system, offering an attractive payback.

Motivations for Installing Commercial Solar PV in Wisconsin

While Wisconsin's geographic potential for solar energy is moderate, the effective load carrying capacity (ELCC) for photovoltaic applications in the state is excellent. According to NREL, which used utility load shape characteristics to map the ELCC for photovoltaics across the nation, "The intensity of the solar resource is obviously critical to PV power generation. But in determining PV's value to a utility, the magnitude of the sun's intensity is less important than its relationship to load requirements."[4] Three characteristics of areas with a high ELCC are occurrence of intense summer heat waves, high daytime commercial power demand, and low demand for electric heat. Fitting this description well, Wisconsin mapped out in the two highest categories (60% -- 100%), where the state's power demand curve is matched with the power production curve of solar electricity.

---

[3] Solarbuzz Inc., *US Grid Connect PV Market Report: A Review of 2003 Performance: A Look Forward to 2004 Outcomes*, May 2004. Citation for Report: http://www.solarbuzz.com/USGridConnect2004.htm

[4] U.S. DOE National Renewable Energy Laboratory, *Photovoltaics Can Add Capacity To The Utility Grid*, DOE/GO-10096-262 DE96000544, September 1996, www.nrel.gov/ncpv/documents/pv_util.html.

Barriers to Development of the Commercial Solar PV Market in Wisconsin
There are several significant barriers to realizing the full potential of commercial solar PV in Wisconsin.

- Wisconsin is already ahead of many states with its new interconnection rule, which offers a consistent structure for grid connection of customer sited solar PV (and other distributed generation) systems. However, for commercial systems, the current net metering maximum of 10 kW can reduce the incentive for businesses to install larger systems. A more favorable utility rate structure will be necessary to fully realize the potential for commercial solar PV in Wisconsin.
- Both business owners and utilities need to become more aware of how solar PV works, and how it could benefit their energy bottom line over time. Perceptions of solar PV need to be updated to reflect advances in technology and changing energy economics.
- Public policy and support has been found to be essential to jump start new renewable energy markets. A clear commitment to renewable energy on both state and federal levels will be necessary.
- The number of installers in or near Wisconsin qualified to do large commercial systems will need to be increased.
- Supply of PV panels available – internationally there is a shortage of PV panels. This situation will probably be rectified as production comes up to meet demand.

Likely Adoption Scenario for Commercial Solar PV in Wisconsin
Businesses most likely to install a solar PV system on an existing structure will be those who occupy their own building or facility, or those who own rental or leased properties where they pay the utility bills. For new construction, building integrated PV (BIPV) will also likely be employed for owner-occupied buildings where solar PV systems are part of an overall green building approach which includes energy efficiency and other renewable energy strategies.

Widespread adoption of solar PV within this defined market segment will depend on the removal of the significant barriers stated earlier. Therefore, the achievable potential of this market will range from that available under the status quo scenario up to what can be reasonably deployed when these barriers are removed.

Program strategies can contribute significantly to barrier reduction. Primary to this goal are raising customer awareness through information, facilitation and training, and participating with utilities and the Public Service Commission in developing commercial rate structures that support the expansion of distributed generation in general and solar PV in particular. The latter would be similar to the cooperative effort that created the recent interconnection rule.

Data to look for:

1. Square feet of flat, owner-occupied commercial roofs in Wisconsin
2. Square feet of leased, flat commercial roofs in Wisconsin where owner pays utilities

3. Square feet of new commercial or institutional space is projected for owner occupancy
4. Average loads per square foot -- What types of commercial businesses are likely to have a high electricity load? What percentage are they of the total?
5. How many square feet of PV panels to serve average commercial customer with 50% of power needs?
6. How many square feet of panels to serve summer peak of average commercial load?
7. What typical peak rate situation works out best for PV?
8. What about battery back-up systems – are they still a leading edge technology for commercial solar PV?

2. Solar Thermal Systems

Like solar PV, solar water heating systems use flat plate, or non-concentrating solar collectors. Therefore the solar resource for water heating in Wisconsin is "good," ranging from 4.0 to 5.0 kWh per square meter per day.

A. Commercial Solar Thermal Systems

Motivation for installing Commercial Solar Thermal Technologies in Wisconsin

The solar resource in Wisconsin is sufficient to provide 40-50% of the energy required to heat water used in commercial businesses and institutions. Where water use is high, the savings are potentially significant. The most common source of energy for heating water in Wisconsin is natural gas. Prices of natural gas are volatile, but are generally rising. Payback calculations of ten years or less for installation of solar thermal technologies are rapidly becoming common, making this a reliable source of savings for the commercial sector.

Barriers to Development of the Commercial Solar Thermal Market in Wisconsin

- Businesses are generally unaware of the potential energy savings available from using solar heated water
- Awareness and acceptance of new business models that allow business owners to turn to a "solar utility" for hot water rather than installing and maintaining a systems themselves, and availability of venture capital to develop such utilities.

Likely Adoption Scenario for Commercial Solar Thermal in Wisconsin

Businesses benefiting the most from solar-heated water are those that use large volumes of hot water. These include car washes, hotels, health clubs, recreational facilities, and restaurants. Public institutions could also benefit including hospitals, nursing homes and retirement communities, college athletic facilities, public pools and transportation maintenance facilities. Factories that use warm or hot water in their manufacturing processes are also potential candidates. Multi-family housing with central water heating systems can also benefit from solar thermal technology.

Data to look for:

- Identify number of businesses and institutions in each of the categories identified above, along with approximate water usage for each.
- Find information about projected trends for business expansion among the appropriate sectors in Wisconsin for the next five to ten years.

B. Residential Solar Thermal Systems

According to typical industry rules of thumb as laid out in Home Power Magazine,[5] panel area requirements for a solar water heating system based on climatic regions compare as follows:

Region	Sq ft/gal of tank capacity*	Total square feet
Sunbelt	1 sq ft/ 2 gal	40
Southeast/Mountain States	1sq ft/1.5 gal	60
Midwest/Atlantic States	1 sq ft/1 gal	80
New England/Northwest	1 sq ft/ .75 gal	107

*Based on a household of four requiring an 80-gallon tank. These are general estimates. A specific analysis is required based on incoming water temperature, hot water temperature setpoint, actual usage and intensity of solar resource on site

The sizing of these systems is intended to provide 100 percent of hot water in the summer and about 40% in the winter. Obviously, water conservation measures can improve the savings (and payback) potential. Solar systems are usually installed to augment the existing water heater so the home never runs out of hot water, but levels of use will determine what percentage of its hot water is solar heated.

In American households, heating water is a major energy expense. A typical electric water heater can easily use more than twice the electricity required by a refrigerator.

Motivations for Installing Solar Thermal Technologies in Wisconsin

- A solar thermal system can offset a significant portion of utility costs for heating water for a household in Wisconsin.
- Value of system added to resale value of house – can be recouped totally when house is sold (National Remodelers Assn)

Barriers to Development of the Residential Solar Thermal Market in Wisconsin

- Lack of system standardization: large variety of systems available can be confusing to public; systems tend to be "custom"[6]
- Number of installers available for this

---

[5] Olson, Ken, Solar Hot Water: A Primer, 2001, Home Power Magazine #84, August/September 2001. Download at http://www.homepower.com/files/olson84.pdf

[6] Solar Hot Water: A Conversation with Drew Gillett and Henry Vandermark, Fall 2000 issue of the Northeast Sun, published by the Northeast Sustainable Energy Association. Download at: http://www.nesea.org/publications/NESun/solar_hot_water.html

- Getting plumbers interested in learning the other aspects required for installation
- Consumers are not accustomed to doing life-cycle analysis on hot water costs
- Consumers lack faith because of outdated perceptions of the solar hot water industry

Likely Adoption Scenario for Residential Solar Thermal in Wisconsin

Installation of a residential solar water heater in Wisconsin is still most cost effective on new homes. However, the recent rapid increase in natural gas prices may soon make installation on an existing home very cost effective. The following three adoption scenarios are most likely within the next five years:

- New "green" custom home purchasers: custom home buyers who want to incorporate clean and green energy measures may find that the net monthly mortgage cost of their solar water heater is lower than what they would pay per month for electric or even gas-heated water.
- "Green" home developers who are already building energy efficient housing developments can offer a solar hot water system as an option in their appliance package, and may combine solar hot water with a grid connected solar PV option as a "Zero Energy Home."
- Owners of existing homes (with sufficient solar access) who are feeling the pinch of rising natural gas prices and wish to save on energy long-term.

Data to look for:

- Estimation of number of existing homes with solar orientation
- Estimation of size of systems needed
- Projection of new homes to be built in Wisconsin over the next five to ten years
- Estimation of how many of these homes could realistically be expected to install solar thermal systems